Participatory Sensing in Sustainable Mobility: biciLAB Model

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Abstract. This project aims to develop a bicycle mobility promotion program and studies to improve urban life through intervention in urban planning and the development of intelligent territories based on bicycle lending systems with the ability to collect statistical information from mobility and other parameters of interest for sustainability and health. The aim is to achieve a long-term operation of the biciLAB under the auspices of the universities and local entities linked to its application within the scope of public policy.

Keywords: Participatory Sensing, Viable System Model, Participatory Sensing Network.

1 Introduction

Displacement is inherent in human activity; however, the way in which it takes place constitutes a cultural and technical feature that determines to a large extent the space of possibilities in which human activity unfolds. The use of pedestrian, public transport, bicycle, motor vehicle or animal traction vehicles is different in each culture, depending on multiple factors such as population density, road infrastructure, terrain, population purchasing power, customs ... but also the will of the citizens and the groups of power.

Regarding bicycle transport, the Netherlands stands out with respect to the rest of the countries, being among the ones of less energy use and less environmental pollution per capita for reasons of transport [1]. Here we also observe that the current use of the bicycle is the result of multiple factors, on the one hand, the country has an urban structure and orography appropriate to this mode of transport; but historically significant trends have also been perceived since World War II. These have been conditioned by industrial interests, the oil crisis of the 1970s and most especially "the national demand in the form of huge demonstrations for the safety of cyclists", which led to the government taking the decision in the 1990s as a popular mandate, to develop a comprehensive Bicycle Master Plan. This mode of mobility (the pedestrian

Preprint version of the article: Díaz-Nafría J.M., Guarda T. (2018) Participatory Sensing in Sustainable Mobility: biciLAB Model. In: Rocha Á., Guarda T. (eds) Developments and Advances in Defense and Security. MICRADS 2018. Smart Innovation, Systems and Technologies, vol 94. Springer, Cham

and cyclist) has a very relevant impact on sociability, sustainability, health and public welfare [2], [3].

The general objective of biciLAB project is to increase the use of bicycles as a means of urban mobility and to use information obtained from bicycle mobility for the development of scientific, technical and community projects aimed at improving urban life and the development of smart territories linked to an active participation of citizens. The development of biciLAB is proposed as a pilot for its application in other cities, particularly in Castilla y León and Portugal (center-north). biciLAB project will be operationalized through the following specific objectives: (i) the development of information and communication systems for the collection of mobility information and the sustainable management of biciLAB according to the Viable System Model (VSM) [4], based on user-friendly technologies and massive open data processing (open data); (ii) the promotion of bicycle mobility within the university community and citizenship, including training activities for the development of a cycling culture and responsible mobility; (iii) the development of public bicycle in the university and in the urban environment, including public infrastructures to cover bicycle mobility; (iv) contribution to the creation of intelligent territories, development and fulfillment of Sustainable Energy and Climate Action Plans (SECAP); (v) the development of interdisciplinary scientific applications based on the biciLAB and devoted the improvement of urban life, which will also be connected to the education of interdisciplinary capacities and community engagement; and (vi) a sustainable management of inter-institutional work based on the VSM.

The achievement of the objectives of the project and the continuity of the biciLAB are based on three fundamental pillars:

(1) The involvement of the university community, citizens and institutions to promote a change in modes of mobility in the area of intervention;
(2) The development of a system of collective bicycles with the capacity to gather information applicable to studies related to sustainability, urban planning, social welfare, etc.
(3) The development of capacities to integrate scientific and community knowledge aimed at coping with complex problems of social concern.

At the same time, as long as the number and diversity of actors and actions is high, a fundamental component for the achievement of results lies in the way of managing organizational complexity. The mode of organization that will be the basis of the whole biciLAB will be the VSM proposed by Staford Beer as a generic mode of organization [9]. In fact, Beer's model is based on the necessary and sufficient conditions that guarantee the organizational sustainability in an adaptive way with respect to the variations of the (external and internal) environment.

2 Background

2.1 Participatory sensing

Participatory sensing is a personal centric participation technique with the inclusion of the citizens in the process, enabling the collection of environmental data with high granularity in space and time [1], [2]. Such process requires the active participation of people (citizens) to voluntarily share contextual information and sensory data, but differently to big-data approaches, to create sense of such data at the operative level of the agents that are cooperating to perform their own a work [3]. This means that the information that is used to handle the problems at a given level is absorbed by the own level in so far as the related issues are fully solved at that level, while the excess information corresponding to issues that require the attention at higher levels percolate upwards.

Participatory sensing networks (PSN) have become popular thanks to the increased use of portable devices, such as smartphones, tablets, iPads, as well as the massive adoption of social networks [3].

The central element of a participatory sensing network is the existence of the citizen capable of performing the sensing with a portable computational device. In this scenario, people participate as social sensors, voluntarily providing data on a particular aspect of a site that implicitly captures their experiences of daily living [4]. These data can be obtained with the aid of sensing devices, such as sensors embedded in smartphones, or through human sensors (subjective observations produced by users).

2.2 Viable System Model (VSM)

The Viable System Model was initially developed by Stafford Beer based on an analysis of the necessary and sufficient conditions of viability of organisms as a paradigm of viability and adaptation to their environment. The model is based on three fundamental principles [4]:

(1) The principle of recursion, according to which any Viable System (VS) is composed of VS (Fig. 1);
(2) The principle of requisite variety according to which the variety of a system must be greater than that of the problem which it affects;
(3) The principle of subsidiarity, according to which the variety is resolved at the lowest (recursive) level, so that only the residual variety percolated above (in the first instance, to the meta system or management bodies of the system; in second instance, to the upper recursive level).

The viability of each nested system means that it is able to autonomously manage the variety of its operational context (solving problems related to its own activity).

In the first approach, three basic elements can be distinguished: the set of operational units that perform the organization's primary activities, those for which the organization is constituted (Fig. 1, 'operations', S1); the meta system or meta-operational level, which is responsible for ensuring that the operating units function in an integrated and harmonic mode (M:={S2, S3, S3*, S4, S5}); and the environment

constituted by all the components of the outside world that are of direct relevance to the system and in which the system is immersed.

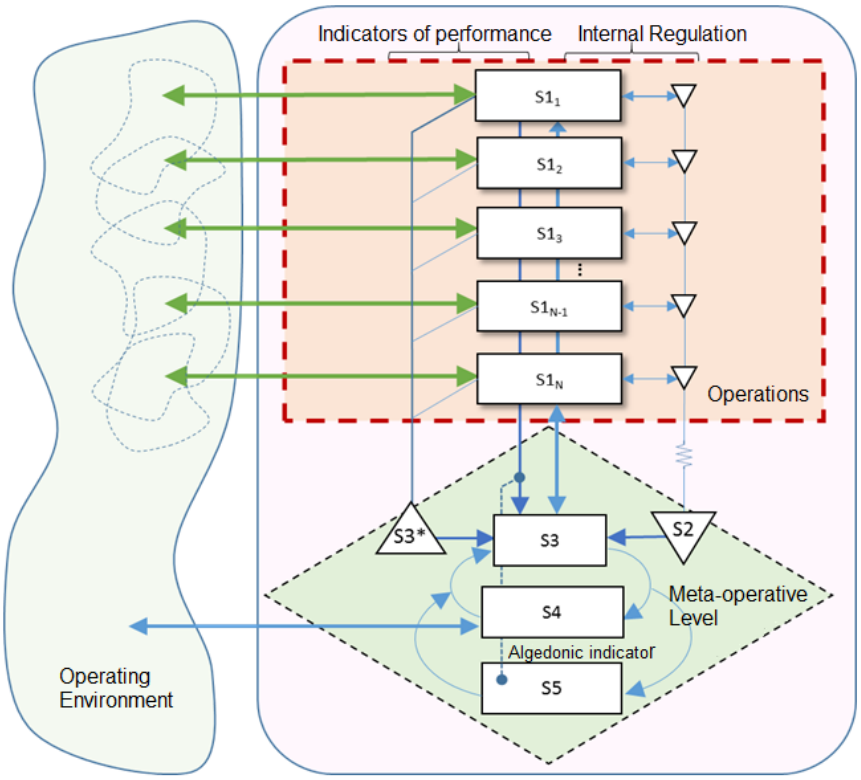

Fig. 1. Viable System Model (MSV) for an adaptive and sustainable organization. The flows of interaction with the outside are represented in green and the information flows in blue. In S2 and S3* the direction of attenuation and amplification are represented symbolically. These have a critical function when it comes to avoiding oscillatory behavior.

According to the analysis of the necessary and sufficient conditions of system sustainability, it must be composed of 5 subsystems that interact with each other, represented in Fig. 1: (S1) every VS contains several primary activities. Each system 1, linked to a particular primary activity, is itself an VS according to the principle of recursion, and performs at least one of the fundamental functions of the organization. (S2) represents the information channels and functions that allow the primary activities in S1 to communicate with one another while facilitating S3 to supervise and coordinate activities in S1. It is responsible for the programming and sharing of resources to be used by S1, conflict resolution and stability. (S3) encompasses the structures and controls arranged to establish S1 rules, resources, rights and responsibilities, guarantee internal regulation, optimize capacities and resources and synergy at the

operational level. It represents the panoramic view of the processes developed in S1 while offering an interface for S4 / S5. Within S3, an audit subsystem (sporadic), System 3* (S3*) can be distinguished. (S4) is composed of those responsible for looking ahead to take charge of changes in the environment and supervise how the organization has to adapt to maintain its viability in the long-term. It has to carry out, therefore, a prospective planning. (S5) is responsible for political decisions in the organization as a whole, balancing the demands of different parties and guiding the organization as a whole.

These subsystems respond to a triple role in the dynamics of operational adaptation: systems 1-3 deal with the "here and now" of the operations of the organization; system 4 deals with "there and then" as a strategic response to external, environmental and future demands; and system 5 deals with balancing the "here and now" and the "there and then" with political and axiological directives that maintain the identity of the organization as a viable entity.

According to the principle of recursion, VS is composed of VS that can be described according to an equivalent systemic description.

$$VS := \{\{S1\}, M \mid S1 := SV; M\ S2, S3, S3\ *, S4, S5\} \quad (1)$$

3 biciLAB Model

In biciLAB project, a sustainable mobility laboratory is proposed based on the capture and processing of mobility information and other parameters of interest for sustainability and health, captured by applications installed on the mobile devices of users of bicycle-sharing systems, and treated in a massive way.

As illustrated in Fig. 2, the biciLAB (located in the center) offers a basic infrastructure for the development of scientific, technological and social innovation projects.

The activity areas corresponding to the specific objectives 1 to 4 constitute an object of "continuous activity", while that corresponding to objective 5 consists of an open framework for the planning and development of interdisciplinary (ID) projects that would be chosen in annual calls, based on quality criteria and adaptation to objectives and priorities.

Thus, the component Information Systems (objective 1) is oriented to the development of the technological infrastructure for the acquisition, management and processing of information and the continuous development of applications that meet the needs of the other components aimed at: Citizen Participation in the context of Participatory sensing (objective 2); the development of Public Bike-Sharing System (objective 3); Urban Planning (objective 4) and the development of interdisciplinary scientific research linked to the objectives of biciLAB through eligible projects (objective 5).

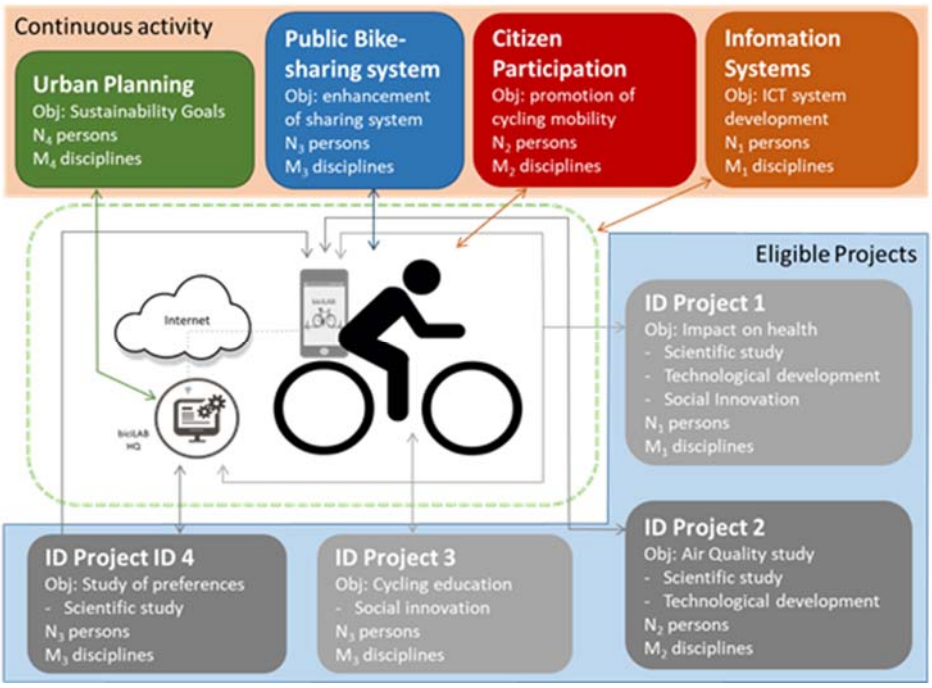

Fig. 2. Basic infrastructure for the development of scientific, technological and social innovation projects.

3.1 Organization and qualification of knowledge integration

The variety and diversity of actors participating in the biciLAB is represented in the figure by the number of actors involved in each component, Ni, and the number of scientific, technical or administrative disciplines involved in the respective activities, Mi. For the orchestration of this variety and multiplicity of actors and disciplines, a model of sustainable management of autonomous work is proposed (based on the Viable System Model) in which the coordination and integral planning of bike-based resources is ensured. Real-time availability of performance information of work teams distributed at various levels of organization, from the eligible projects running in a yearly basis, to the management level of biciLAB as a whole. This structure would be developed within the framework of the project aimed at constituting a pillar for the long-term operation of biciLAB under the auspices of the interested parties. In order to qualify the performance of the biciLAB in terms of its knowledge integration capacity, an innovative approach will be applied, based on the measurement of diversity and the integration of knowledge networks, contributing to the global challenge of qualifying interdisciplinarity.

From this conception, biciLAB represents altogether, on the one hand, a laboratory of social innovation oriented to propitiate a change towards a sustainable mobility from the citizen participation, on the other, an opportunity to develop the interdisciplinarity

and the integration of knowledge coming from diverse scientific, technological, technical, administrative areas and from the own citizenship. This makes it an ambitious project of integral transfer of knowledge for the improvement and sustainability of urban life.

3.2 Technological solution

The technological infrastructure is basically constituted by ad hoc mobile applications operating in users' own mobile devices and the system for acquiring, managing and processing information for its subsequent availability by citizens, public and scientific managers. Fig. 3 offers some additional details about the architecture, highlighting the management of components of mobile devices (top right) that will be managed from the mobile applications of biciLAB.

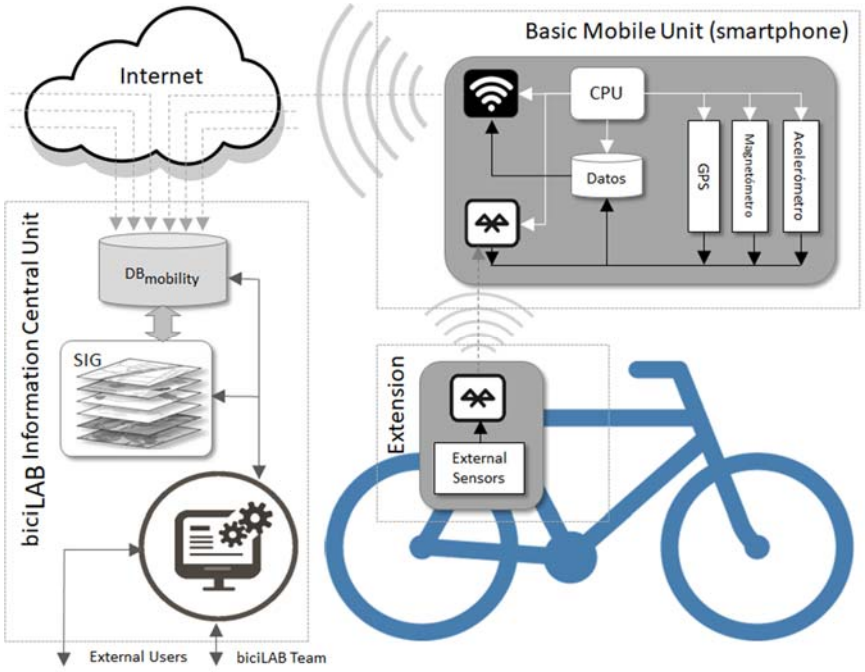

Fig. 3. Mobility data acquisition system as basic infrastructure of biciLAB.

On the one hand, the sensors available on any smartphone offer basic information for the collection of user mobility data. These would be stored in memory and transferred while the device has Wi-Fi access (to avoid the cost to the user caused by the transfer of data under mobile connection with her operator). In order to increase the capacity of gathering information of other types not provided by the sensors available in the user's telephone (eg concentration of certain gases, noise, and pressure on the

pedal axis, etc.) an extension could cover the needs anticipated in specific activities. Its basic structure would simply consist of a Bluetooth module attached to a sensor device. The Bluetooth port, available on the user's phone and managed by the biciLAB application, allows the transfer of information to be subsequently stored and transferred using the same protocols and data structure as for the rest of the information from the own sensors.

4 Conclusions

This document describes the biciLAB project which aims at developing a promotion program of cycling mobility and scientific-technical studies to enhance urban life based on a cycle sharing system with capacity to gather statistical information of mobility and other parameters of interest for the study of health and sustainability. The project includes the intervention in urban planning and the development of intelligent territories oriented to the achievement of Sustainable Energy and Climate Action Plans. According to current planning the biciLAB will be implemented in several metropolitan areas of Spain, Portugal and Ecuador

References

1. MREC: En uso masivo de la bicicleta para el Buen Vivir., : Embajada de Ecuador en los Países Bajos, Amsterdam (2012)
2. Litman, T.: Whose Roads? Evaluating Bicyclists' and Pedestrians' Right to Use Public Roadways. (2012)
3. Molina-García, J., Castillo, I., Queralt, A., Sallis, J.: Bicycling to university: evaluation of a bicycle-sharing program in Spain. Health promotion international 30(2), 350-35 (2013)
4. Walker, J.: The Viable Systems Model - a guide for cooperatives and federations. ICOM, CRU, CAG & Jon Walker (1998)
5. Beer, S.: Diagnosing the System for Organizations. Wiley, New York (1985)
6. Guarda, T., León, M., F., A., Pérez, H., Chavarria, J., O., Orozco, J.: Participative Sensing in Noise Mapping: An Environmental Management System Model for the Province of Santa Elena. In Springer, C., ed. : International Conference on Information Theoretic Security, pp.242-251 (2018)
7. Oldenburg, J., Griskewicz: Participatory healthcare: A person-centered approach to healthcare transformation. CRC Press. (2016)
8. Burke, J., Estrin, D., Hansen, M., Parker, A., Ramanathan, N., Reddy, S., Srivastava, M.: Participatory sensing., UCLA: Center for Embedded Network Sensiing (2006)
9. Giannetsos, T., Dimitriou, T. ., Prasad, N.: People-centric sensing in assistive healthcare: Privacy challenges and directions. Security and Communication Network 4(11), 1295-1307 (2011)